Improving Building Energy System Performance by Continuous Commissioning♦

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The term Continuous Commissioning♦ (CC♦) was first used by engineers at the Energy Systems Lab (ESL), Texas A&M University, to describe an ongoing process which improves the operation of buildings using measured hourly energy use and environmental data. The first buildings to undergo a continuous commissioning♦ process were in the Texas LoanSTAR program. These buildings had been retrofitted with various energy efficiency improvements, and measured hourly data was available to verify that the retrofits were performing as desired, and to analyze the overall building performance. The ESL engineers, using hourly data, site visits, and ESL-developed software worked with the facility engineers to fine-tune the building operation. These efforts were so successful that another 15% to 30% of the annual building energy cost was saved -- and these were in buildings that supposedly had all cost effective retrofits and operating improvements already implemented.

Continuous Commissioning♦ in Retrofitted Buildings

Table 1 gives examples of 10 buildings where the continuous commissioning♦ process was used, and the resulting annual savings. The energy savings were measured by using hourly data. The percentage savings were determined as the cost savings compared to the total annual building energy consumption (chilled water, hot water and electricity). The measured percentage savings varied from 12% to 37% with an average savings of 25% .The measured annualized savings for the 10 buildings were $2,472,700/yr with cumulative savings of $5,323,100 through April 1996.

Table 1. Measured Energy Savings due to Continuous Commissioning in Selected Buildings

Building Type	Floor area (ft^2)	Annualized Savings ($/yr)	Savings (%)	Cumulative Savings Through April 1996 $	Months
Labs, classrooms & offices	233,700	$60,600	12	$126,000	25
Offices,classrooms & labs	887,000	$872,700	24	$1,527,000	21
Medical research	412,800	$153,700	20	$373,800	29
Medical research	120,000	$208,900	30	$504,700	29
Hospital	490,000	$397,800	31	$961,000	29
Hospital	276,000	$209,000	37	$505,000	29
Surgical Center	54,000	$159,000	37	$411,000	31
Offices & Classrooms	138,000	$204,000	32	$579,000	34
Library	67,000	$37,000	17	$53,000	17
Hospital	373,000	$170,000	16	$282,600	20
Total	3,051,500	$2,472,700	25	$5,323,100	

Continuous Commissioning♦ in New Construction

The Continuous Commissioning♦ process has also been extended to new construction at the Texas State Capitol Complex in Austin, Texas. One such building is the Capitol Extension building, which was completed in 1992 as an energy efficient building. It is located next to the state Capitol and contains a covered atrium in the center of the building which houses legislative offices and hearing rooms. The first operational improvements were implemented in July 1995 with additional measures implemented through June 1996. During this period, a total of 15 operational improvements were implemented. The Continuous Commissioning♦ has greatly improved indoor comfort conditions and reduced the total building energy cost by $100,300 over 345 days (July 1, 1995 to June 11, 1996). The measured energy and cost savings are summarized in Table 2.

Table 2: Measured Energy Savings at the Capitol Extension Building (7/1/95 to 6/11/96)

	Energy Savings (MMBtu or kWh)	Cost Savings ($)	Ratio of Savings/Cost
Chilled Water Savings	12,030	$39,100	25 %
Hot Water Savings	7,980	$30,640	53 %
Electricity Savings	616,000 kWh	$30,560	7 %
Total Savings		$100,300	19.3%
Daily Average		$290	--
Total Annual Utility Costs		$520,610	100%

Continuous Commissioning♦ Prior to Retrofits

As a result of the Continuous Commissioning♦ successes in the LoanSTAR program, Texas A&M University committed over one million dollars of its' own money in 1995 to the Energy Systems Laboratory to commission 70 of its' largest buildings, the power plant, and the satellite thermal plants. As of July 1996 the power plant, thermal plants and approximately 30 buildings have been metered, with the remaining buildings to be metered by the end of 1996. To date, several measures have been identified and implemented through the metering and the Continuous Commissioning♦ process, which will result in $750,000 in annual savings. In addition, another $750,000 of measures has been identified and is in the process of implementation. Full implementation of these measures will provide the university with less than a one-year payback on its investment -- and there are still more than 40 buildings to be analyzed. Annual savings from the

fully-implemented campus CC♦ process are estimated to result in a $3 million decrease in the campus energy bill!

Improved operation and control measures have been partially implemented in 10 buildings, where significant energy reduction has been observed. Figures 1 & 2 compare the measured chilled water and hot water consumption before and after Continuous Commissioning♦ began at one of the buildings.

Continuous Commissioning♦ and Retrofits

Both Continuous Commissioning♦ and retrofits can reduce building energy consumption and improve the building comfort conditions. We have found that Continuous Commissioning♦ can often provide as much or more savings than retrofits. Figure 3 presents the annual energy costs in three facilities where extensive building energy retrofits were performed before Continuous Commissioning♦ began. The Continuous Commissioning♦ process was every bit as important as the energy retrofits in these facilities.

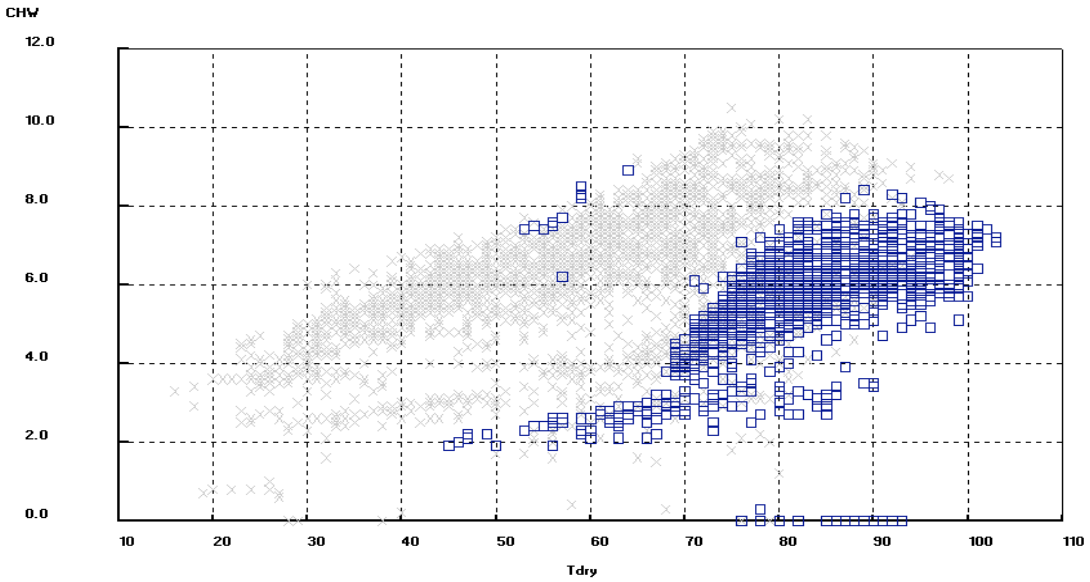

Figure 1: Comparison of Measured Chilled Water Consumption(MMBtu/hr) before ("x") and after ("□") Continuous Commissioning in a Campus Building.

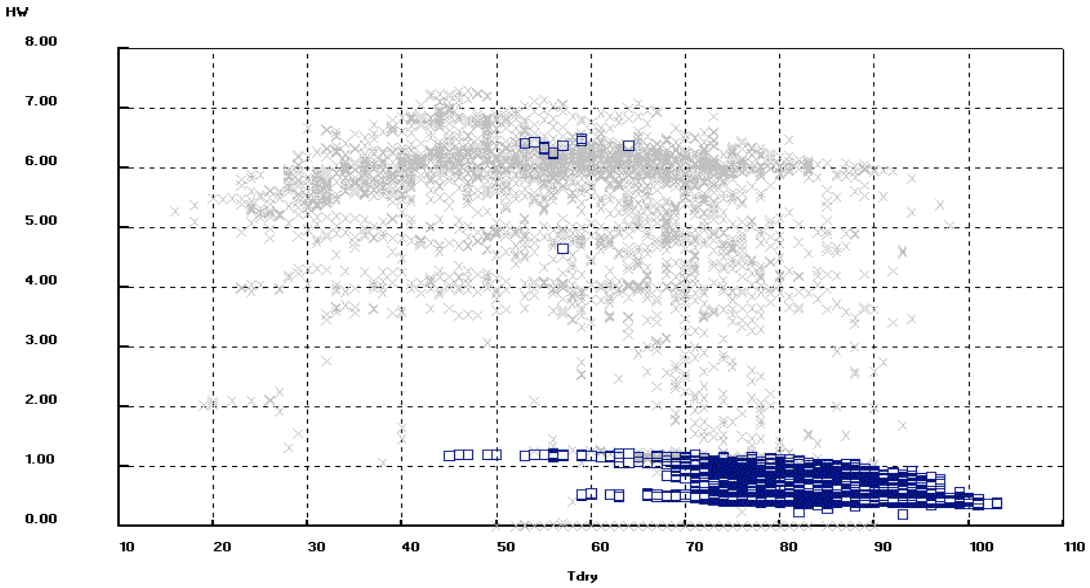

Figure 2: Comparison of Measured Hot Water Consumption (MMBtu/hr) before ("x") and after ("□") Continuous Commissioning in a Campus Building.

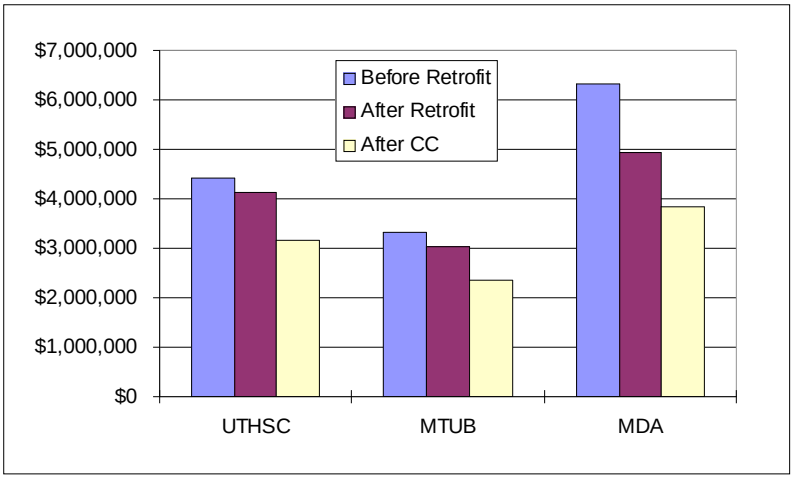

Figure 3: Energy Cost Before Retrofit, After Retrofit, and After Retrofit and CC.

There are several important reasons why Continuous Commissioning♦ should be the first stage in an energy efficiency program. First, the evidence in study after study consistently shows that almost every building can be made more efficient, improving comfort as well as reducing energy consumption. In some instances, a building's energy consumption can be reduced such that some retrofits will not be necessary (or cost effective). Another reason for Continuous Commissioning♦ before retrofitting is that an improved energy consumption baseline can be established. A more accurate determination of actual savings from retrofits can be made if metered data and a good calibrated air-side building simulation model are available. From experience, there is little doubt that the Continuous Commissioning♦ process is highly cost effective and is the preferred approach prior to a major retrofit program.

Continuous Commissioning♦, Comfort, and Indoor Air Quality

It is not unusual to have indoor air quality and other comfort problems in existing buildings. Since the IAQ and comfort problems influence the productivity of office workers, Continuous Commissioning♦ should resolve these problems before targeting energy savings, although it is hard to accurately evaluate the actual dollar savings from improved comfort.

In one building, the room relative humidity was as high as 70%, and the room temperature varied from 68F to 77F from zone to zone. After commissioning, the building relative humidity was held below 55%, and room temperatures were controlled within 1°F of the set point. During a second visit to the building, the building's occupants mentioned a noticeable improvement in the indoor conditions.

Do the improved indoor conditions come at the expense of increased energy consumption? Comparison of the energy bills before and after the continuous commissioning process showed a reduction in electricity use of about 20% following implementation.

Continuous Commissioning♦ to Outperform the Design Performance

The Continuous Commissioning♦ process is not just the usual cookbook of O&M measures often used in the building recommissioning program. Innovative ideas can often be implemented in an existing facility, which can result in significant energy savings. In 1994, hot duct air pressure control was implemented by using a hot air damper in an existing facility. Although the building was operated based on the specified design requirements, this new measure reduced the building total energy cost by

$182,000/yr or 16% of the total energy cost. This measure also eliminated the hot spots in the building.

Typical Measures from the Continuous Commissioning♦ Process

The Continuous Commissioning♦ process is not just the usual cookbook of O&M measures often used in building recommissioning programs. Roughly 80% of the CC♦ measures involve control systems changes and thus are highly effective in buildings containing an EMCS. Measures might include optimized hot and cold deck reset schedules, changes in outside air settings (after appropriate CO_2 measurements are made), reduction in static duct pressures, variable speed drives, and in certain instances, changes in specific control strategies. To accomplish effective CC♦ , engineers work closely with Physical Plant personnel to determine what will work and what changes the building personnel are comfortable in making. A team effort has to be established in the CC♦ process, but the results documented herein clearly establish the success of the CC♦ process.

If state buildings in Texas cost $300,000,000 annually in utility bills statewide, then it is estimated that CC♦ can conservatively save $30,000,000(10%) to $60,000,000(20%) of the state's annual utility bills.